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(54) **FUEL INJECTION DEVICE**

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(73) Assignee: **DENSO CORPORATION**, Kariya (JP)

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Sep. 12, 2011 (JP) 2011-198460

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F02M 47/02 (2006.01)

(52) **U.S. Cl.**
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USPC 239/533.2, 88, 57–59, 482–486, 600, 239/585.1, 585.5; 251/30.05, 30.02, 251/129.15; 123/447, 90.65, 275, 261, 445, 123/429, 431, 510, 511, 442, 467–470, 456
See application file for complete search history.

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(57) **ABSTRACT**

A fuel injection device includes a cylinder defining a pressure chamber at an end portion of a nozzle needle. In the cylinder, a floating plate is provided as a controlling member of fuel pressure. An orifice member and a nozzle body are lined by an annular positioning member, using a circular peripheral surface of the orifice member and a circular peripheral surface of the nozzle body as a reference surface. Thereby, radial locations of the nozzle body and the orifice member are defined. Furthermore, a location of the floating plate is defined by the nozzle body with the nozzle needle. Therefore, the floating plate can be located to a proper location relative to the orifice member.

15 Claims, 8 Drawing Sheets

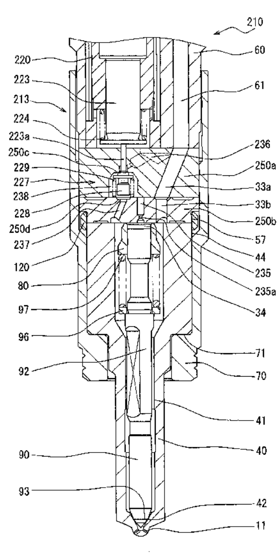

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FIG. 1

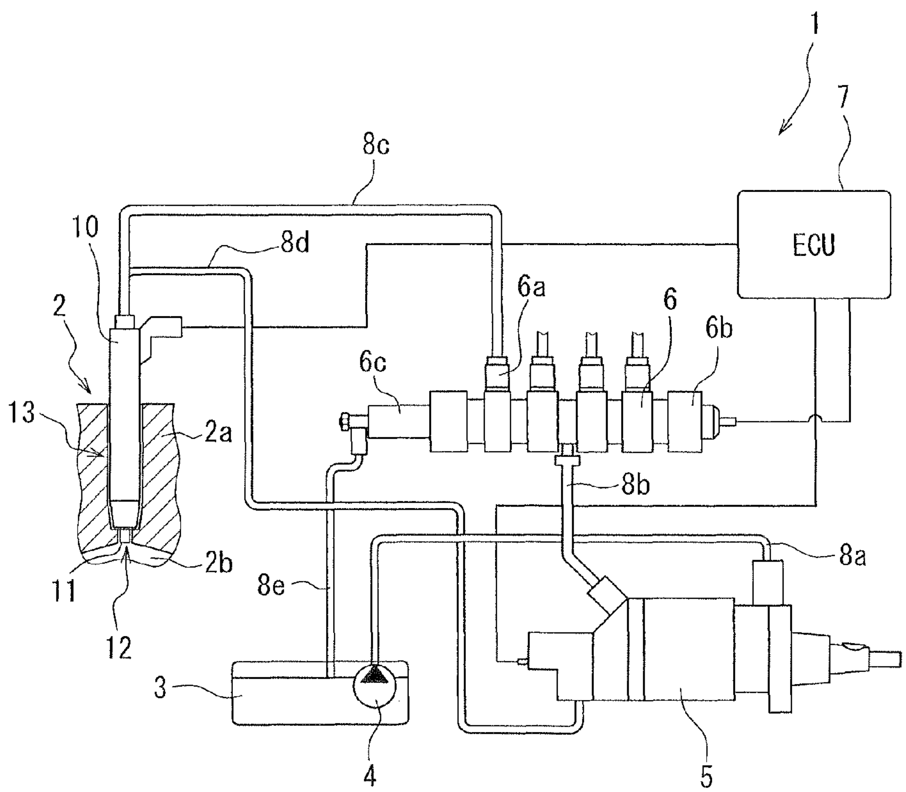

FIG. 2

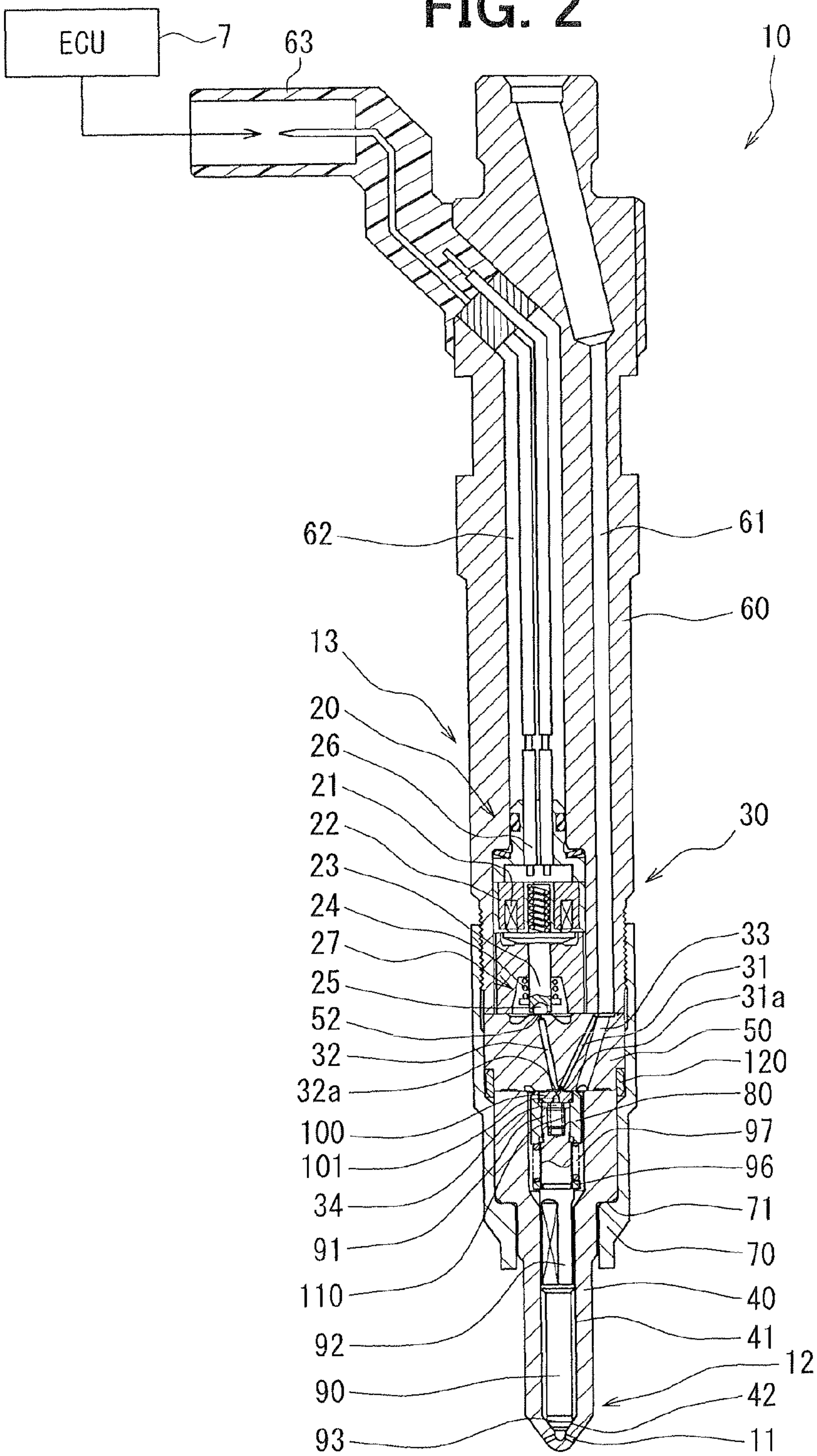
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FIG. 3

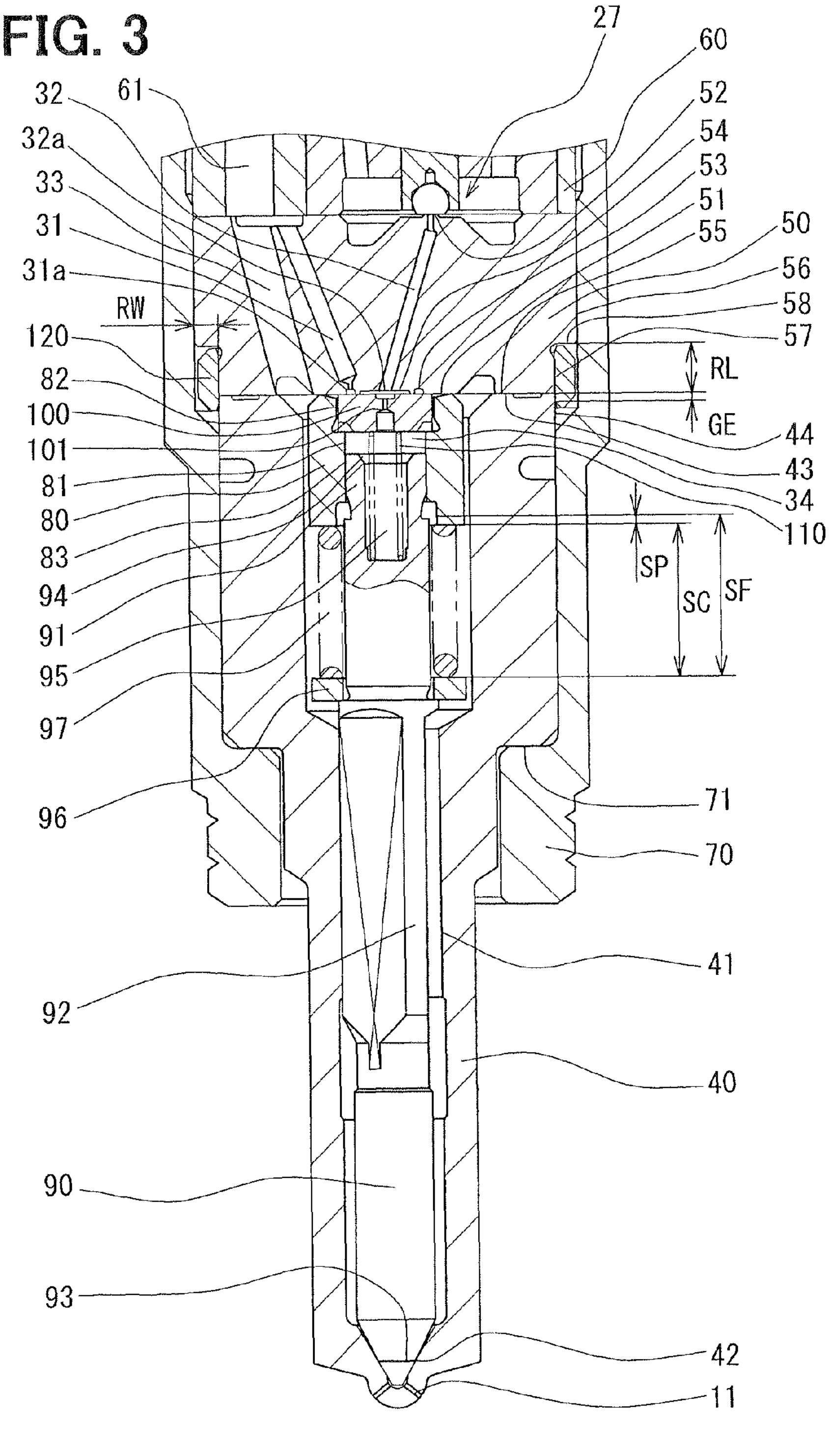
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FIG. 4

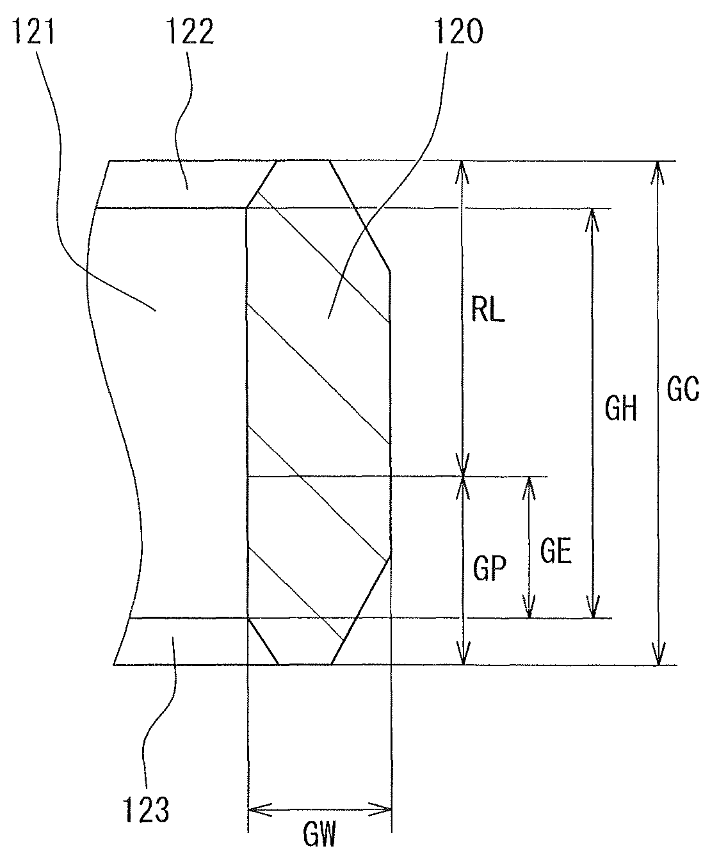

FIG. 5

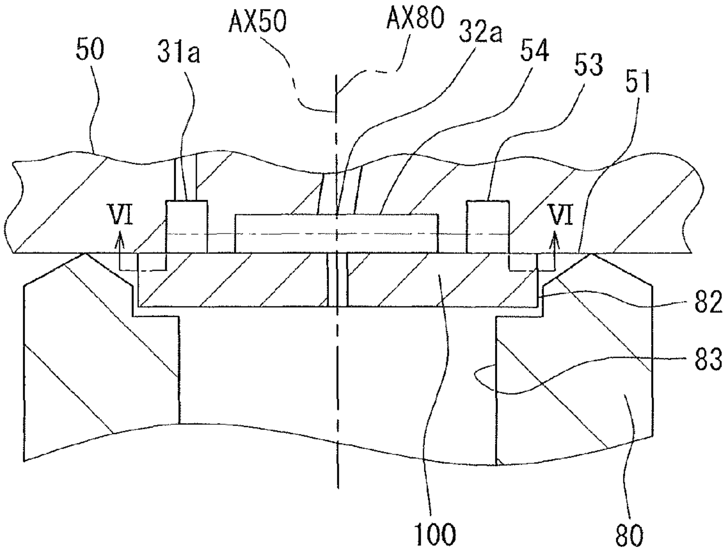
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FIG. 6

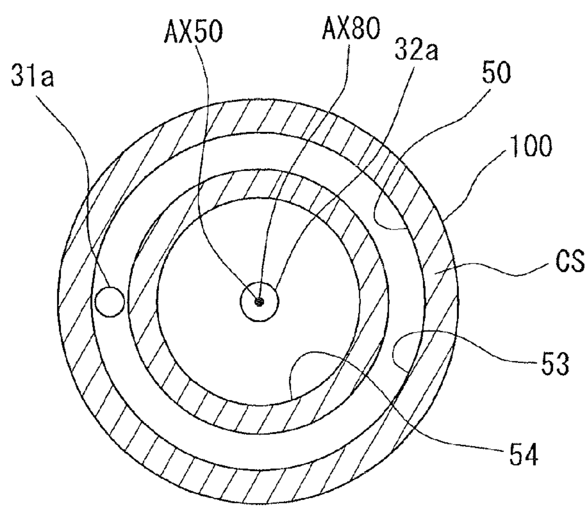
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FIG. 7 RELATED ART

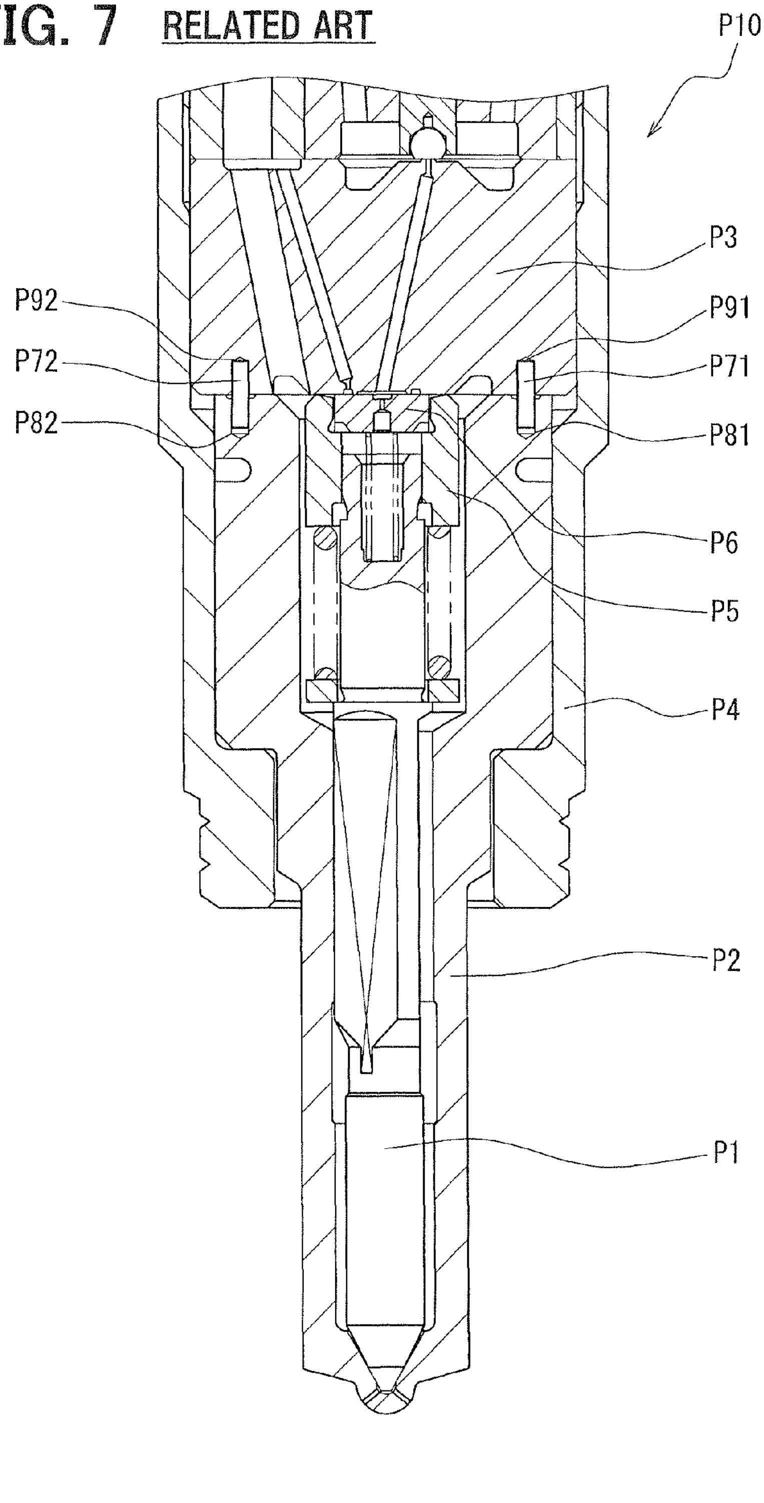


FIG. 8 RELATED ART

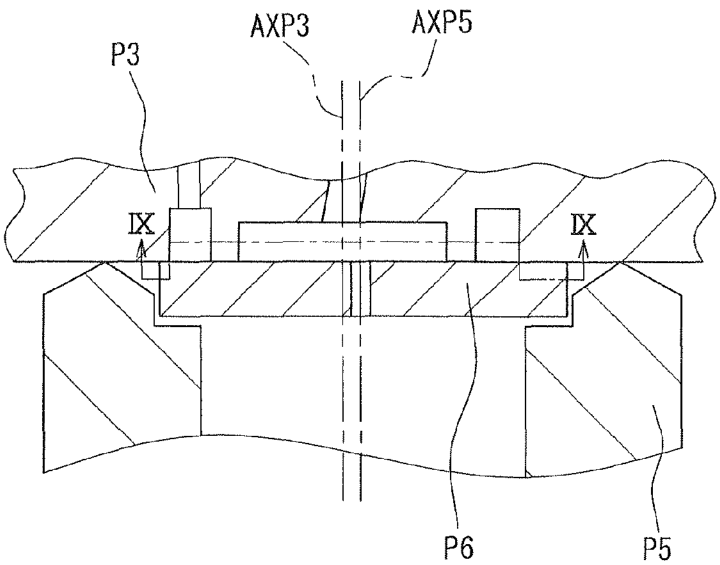


FIG. 9 RELATED ART

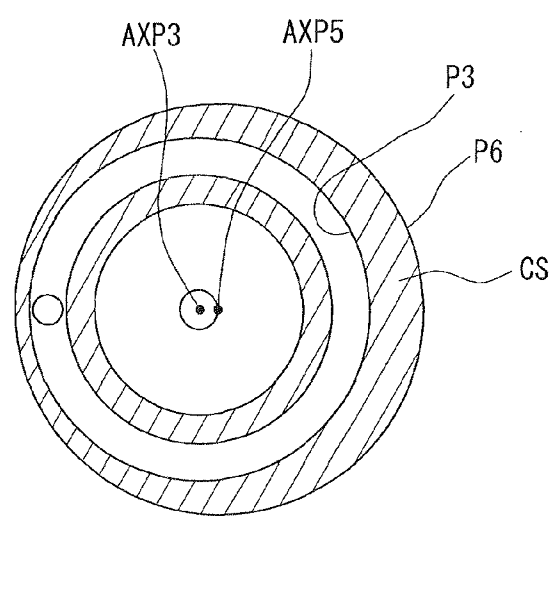
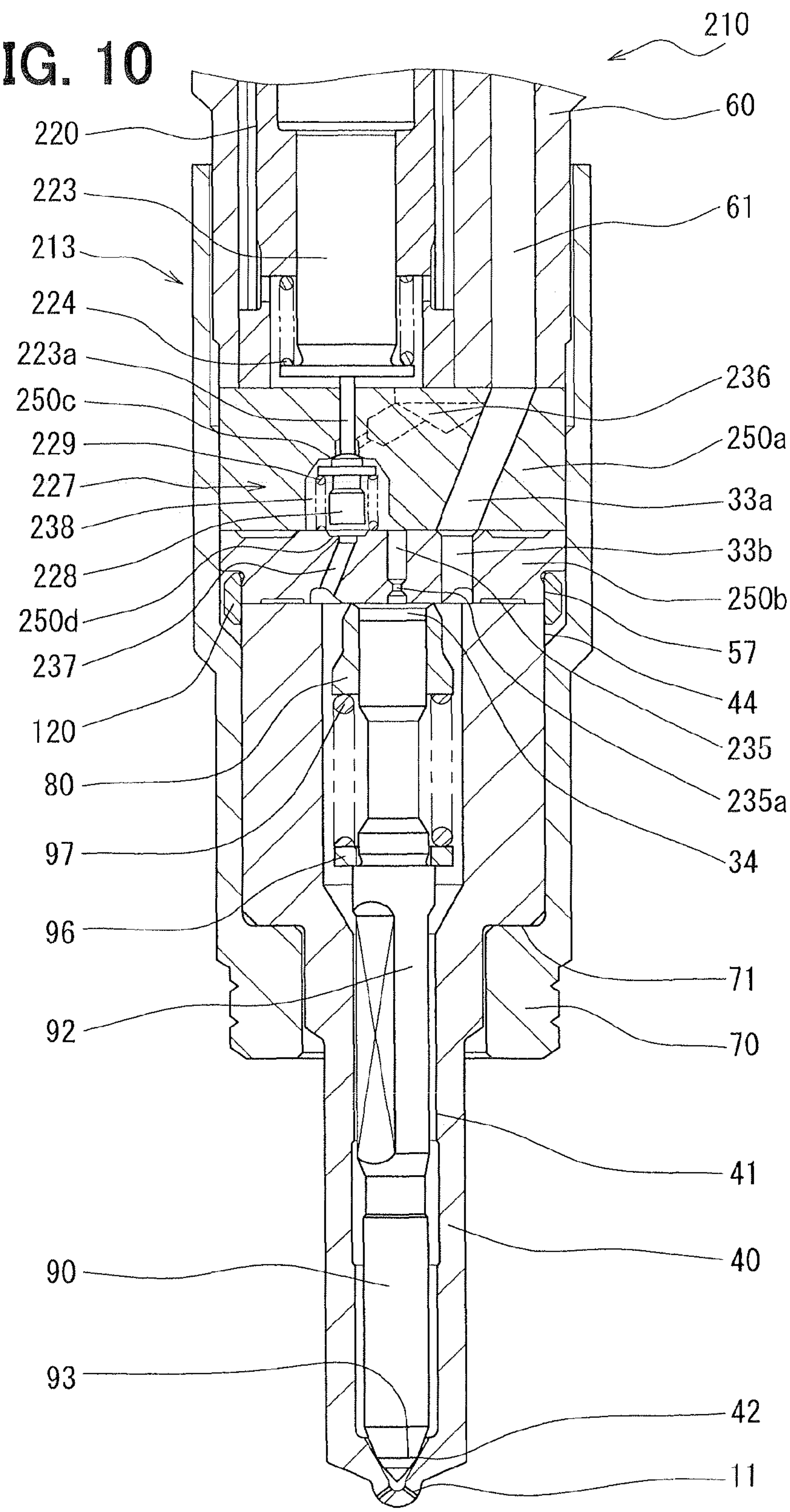


FIG. 10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FUEL INJECTION DEVICE

CROSS REFERENCE TO RELATED APPLICATION

This application is based on Japanese Patent Applications No. 2010-281996 filed on Dec. 17, 2010, and No. 2011-198460 filed on Sep. 12, 2011, the contents of which are incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present invention relates to a fuel injection device, which controls fuel pressure applied to a valve member that allows or interrupts fuel injection from injection holes.

BACKGROUND ART

Patent documents 1 to 3 (EP 1656498B1, JP 06-108948A, JP 4054621B2 (corresponding to US 2003/0052198A1)) describe regarding fuel injection devices that have a pressure chamber and a pressure control mechanism. The pressure chamber applies fuel pressure to a valve member that allows or interrupts fuel injection from injection holes. The pressure control mechanism controls the inside pressure of the pressure chamber to move the valve member. In the fuel injection devices, it is proposed to use a pressure-response type control member as the pressure control mechanism, which moves in response to the change of pressure caused by the opening and closing of a solenoid valve. In this type of the fuel injection device, for achieving expected performance, each component of the fuel injection device needs to be positioned accurately at each proper location.

SUMMARY OF INVENTION

In view of the foregoing matters, it may be considered to use pins for arranging the components of the fuel injection device in proper positions. FIG. **7** is a cross-sectional view of a fuel injection device P**10** that uses alignment pins as a comparative example of the present invention. A needle P**1** is held in an inside of nozzle body P**2** to open and close injection holes. The nozzle body P**2** includes the injection holes. The nozzle body P**2** is fixed to an orifice member P**3** by a retaining nut P**4**. A cylinder P**5** is provided in an inside of the nozzle body P**2**. An end portion of the needle P**1** is inserted into the cylinder P**5** as a piston. The cylinder P**5** is pressed to the orifice member P**3**. A pressure chamber is defined in an inside of the cylinder P**5**. A floating plate P**6** is provided in an inside of the pressure chamber as a control member. The floating plate P**6** controls inflow of the fuel into and outflow of the fuel from the pressure chamber.

Pins P**71**, P**72** are provided in a location between the nozzle body P**2** and the orifice member P**3**. The pins P**71**, P**72** make the nozzle body P**2** and the orifice member P**3** positioned at proper locations. Hole portions P**81**, P**82** are arranged in the nozzle body P**2**. The hole portion P**81** holds the pin P**71**, and the hole portion P**82** holds the pin P**72**. Hole portions P**91**, P**92** are arranged in the orifice member P**3**. The hole portion P**91** receives the pin P**71**, and the hole portion P**92** receives the pin P**72**.

However, alignment structure using the pins P**71**, P**72** has factors that may cause errors. Dislocation between the nozzle body P**2** and the orifice member P**3** is caused by, for example, the positioning errors of the hole portions P**81**, P**82**, P**91**, P**92**, the size errors of the hole portion P**81**, P**82**, P**91**, P**92**, and the size errors of the pins P**71**, P**72**, and so on.

For example, the dislocation of the nozzle body P**2** and the orifice member P**3** deteriorates the location accuracy of the nozzle body P**2**. The above described dislocation may cause change in a state of communication between fuel passages. Therefore, the above described dislocation may cause the change of a characteristic of the fuel injection. In addition, the variations of the characteristic of the fuel injection may occur in each product. This kind of problem may occur in both the fuel injection device using the cylinder P**5** and the fuel injection device not using the cylinder P**5**. Furthermore, this kind of the problem may occur in both the fuel injection device using a pressure-response type control member and the fuel injection device not using the pressure-response type control member.

In the fuel injection device using the cylinder P**5**, the dislocation of the nozzle body P**2** and the orifice member P**3** causes, for example, the radial dislocation of the orifice member P**3** and the cylinder P**5**. Due to this kind of the dislocation, the desired performance of the fuel injection may not be achieved. In addition, the variations of the characteristic of the fuel injection may occur in each product.

The dislocation of the nozzle body P**2** and the orifice member P**3** may cause a significant influence on the fuel injection device including the floating plate P**6**. FIG. **8** is a partially enlarged cross-sectional view of the fuel injection device of the comparative example that has a gap between components. FIG. **9** is a plane view of the fuel injection device of the comparative example that has the gap between the components. When the dislocation of the nozzle body P**2** and the orifice member P**3** is caused, a center axis AXP**3** of the orifice member P**3** and a center axis AXP**5** of the cylinder P**5** are moved from their proper locations. At this time, as shown in FIG. **9**, a contact section (CS) between the orifice member P**3** and the floating plate P**6** is biased in the radial direction thereof. In addition, the amount of the bias is not in uniform. Thereby, deviation is caused in the pressure applied to the floating plate P**6**. As a result, the floating plate P**6** may not achieve a desired performance thereof. Specifically, a desired fuel injection characteristic may not be achieved. Furthermore, the motion of the floating plate P**6** may become unstable, so that the fuel injection characteristic may not be stable. Moreover, the motions of the floating plate P**6** may vary in each product to cause differences of the fuel injection characteristic between them.

In view of the foregoing and other matters, it is an object of the present invention to provide a fuel injection device in which the components are positioned accurately in the radial direction thereof.

Another object of the present invention is to provide a fuel injection device in which the components are positioned accurately in the radial direction thereof with a structure that has high productivity.

Another object of the present invention is to provide a fuel injection device that achieves a stable fuel injection characteristic.

Another object of the present invention is to provide a fuel injection device that achieves the stable fuel injection characteristic with a structure ensuring high productivity.

One of the specific objects of the present invention is to improve the fuel injection characteristic in a fuel injection device that includes a cylinder defining a pressure chamber.

Another one of the specific objects of the present invention is to improve the fuel injection characteristic of a fuel injection device that includes a cylinder in which a control member is arranged.

According to a first aspect of the present disclosure, a fuel injection device is provided with a valve body, a valve member, a housing member, a control member and an annular positioning member. The valve body has therein a passage for a high-pressure fuel, and is provided with injection holes that are arranged at a tip end of the valve body to inject the high-pressure fuel to an inside of a combustion chamber of an internal combustion engine. The valve member moves in an axial direction of the valve body therein to allow or interrupt a supply of the high-pressure fuel to the injection holes. The housing member is provided to face to an end of the valve body and to define a pressure chamber, which controls movement of the valve body by adjusting fuel pressure applied to the valve body, and forms control passages through which fuel flows for controlling the fuel pressure in the pressure chamber. The control member is provided in an inside of the pressure chamber and contacts and detaches from the housing member to at least allow or interrupt a communication between an inflow passage and the pressure chamber, in which a radial location of the control member is defined by the valve body. The annular positioning member is fixed to a circular peripheral surface of the valve body and fixed to a circular peripheral surface of the housing member to set locations of the valve body and the housing member in a radial direction thereof.

In this configuration, the valve body and the housing member are set accurately to proper locations in these radial direction by the annular positioning member. Thereby, instability of the fuel injection characteristic, which is caused by the dislocation of the valve body and the housing member, can be limited.

According to a second aspect of the present disclosure, at least one of the valve body and the housing member may have a stepped surface that sets the location of the positioning member in the axial direction. In this configuration, the positioning member is set accurately to the proper location in the axial direction.

According to a third aspect of the present disclosure, an axial length (GC) of the positioning member may be larger than an axial length (RL) of the circular peripheral surface that is adjacent to the stepped surface such that GC>RL. In this configuration, fixing the positioning member to the valve body or the housing member makes the positioning member project from the valve body or the housing member. Therefore, fixing the positioning member to the valve body or the housing member becomes easy to be performed.

According to a fourth aspect of the present disclosure, a return spring may be provided between the housing member and the valve member to urge the valve member to a valve-close direction. An axial length (RL) of the circular peripheral surface and an axial length (GC) of the positioning member may be set such that a length (GP) of the projection of the positioning member projecting in the axial direction from the circular peripheral surface is larger than a compression amount (SP) of the return spring (GP>SP). In this configuration, even if the length of the return spring is equal to a free length, the projecting portion of the positioning member can be fixed to the valve body or the housing member.

According to a fifth aspect of the present disclosure, a thickness (GW) of the positioning member may be less than or equal to a width (RW) of the stepped portion such that GW≤RW. In this configuration, the positioning member can be received within the area of the stepped portion in its radial direction.

According to a sixth aspect of the present disclosure, the positioning member may have a slope that guide at least one of valve body and the housing member to a fixing portion. In this configuration, the slope guides at least one of the valve body and the housing member to its fixing portion. Thereby, inserting at least one of the valve body and the housing member into the inside of the positioning member becomes easy to be performed.

According to a seventh aspect of the present disclosure, the positioning member may be fixed to an outer circular peripheral surface of the valve body and fixed to an outer circular peripheral surface of the housing member to cover the valve body and the housing member. A fixing member may be provided radially outside of the positioning member to fix the valve body and the housing member in the axial direction. Furthermore, the positioning member may be held in the axial direction by the fixing member. In this configuration, the positioning member can be held in its axial direction by the fixing member, such as a retaining nut, which fixes the valve body and the housing member in the axial direction.

According to an eighth aspect of the present disclosure, the fuel injection device may further include a cylinder that holds a piston portion arranged at an end portion of the valve body, and may be located to urge the housing member and to define the pressure chamber together with the housing member. Furthermore, a radial location of the cylinder may be set by the valve member, and a radial location of the valve member may be set by the valve body. In this configuration, the radial location of the cylinder that urged the housing member can be set by the location of the nozzle body with the valve member. The valve body and the housing member are set accurately to proper locations respectively by the positioning member, and thereby the cylinder is also set accurately relative to the housing member.

According to a ninth aspect of the present disclosure, the control passage may include an inflow passage, which introduces fuel to the pressure chamber, and an outflow passage, which discharges the fuel out of the pressure chamber. Furthermore, a control member may be provided in an inside of the pressure chamber and contacts and detaches from the housing member to at least allow or interrupt a communication between the inflow passage and the outflow passage. A radial location of the control member may be defined by the valve body, and a radial direction of the control member may be defined by the cylinder. The housing member and the control member may configure a flat sealing surface that allows or interrupts a communication between the inflow passage and the pressure member. In this configuration, the radial location of the control member can be defined by the nozzle body with the cylinder and the valve member. That is, the control member and the housing member can be set accurately to proper locations, respectively. The flat sealing surface is provided between the housing member and the control member to allow the dislocation of the control member in the radial direction thereof. Even in this structure, the control member can be set to the proper location. Therefore, it can prevent the sealing surface of the flat sealing from being biased relative to the housing member. Thereby, the instability of the fuel injection characteristic, which is caused by the dislocation of the housing member and the control member, can be limited.

According to a tenth aspect of the present disclosure, the control passage may include a common supply passage that is commonly used for introducing fuel into and discharging the fuel out of the pressure chamber. In this configuration, the valve body and the housing member can be set to proper radial locations even in the fuel injection device including the common passage.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

FIG. **1** is a block diagram of a fuel supply system according to a first embodiment in the present invention;

FIG. **2** is a cross-sectional view of a fuel injection device of the first embodiment;

FIG. **3** is an enlarged cross-sectional view of the fuel injection device of the first embodiment;

FIG. **4** is an enlarged cross-sectional view of the fuel injection device of the first embodiment;

FIG. **5** is an enlarged cross-sectional view of a proper alignment of the fuel injection device in the first embodiment;

FIG. **6** is a plane view of the proper alignment of the fuel injection device of the first embodiment;

FIG. **7** is a cross-sectional view of a fuel injection device of a comparative example;

FIG. **8** is an enlarged cross-sectional view of the fuel injection device of the comparative example that has a gap between components;

FIG. **9** is a plane view of the fuel injection device of the comparative example that has a gap between components; and

FIG. **10** is an enlarged cross-sectional view of a fuel injection device of a second embodiment according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Various embodiments of the present invention will be described with reference to the accompanying drawings. In the following embodiments, similar components are indicated by the same reference numerals and will not be redundantly described to simplify the description. In each of the following embodiments, if only a part of a structure is described, the remaining part of the structure is the same as that of the previously described embodiment(s). Any one or more components of any one of the following embodiments may be combined with the components of the other one of the following embodiments without departing a scope and spirit of the present invention.

First Embodiment

FIG. **1** is a block diagram of a fuel supply system **1** according to a first embodiment in the present invention. A fuel injection device **10** of the first embodiment is used in the fuel supply system **1**. The fuel supply system **1** supplies fuel to an internal combustion engine **2**. The combustion engine **2** is a multi-cylinder diesel engine. A head member **2***a* of the combustion engine **2** defines a combustion chamber **2***b*. The fuel supply system **1** is a direct injection fuel supply system. The fuel injection device **10** injects fuel directly to an inside of the combustion chamber **2***b*. The fuel supply system **1** includes a fuel tank **3**, a feed pump **4**, a high-pressure fuel pump **5**, a common rail **6**, an electric control unit (ECU) **7**, and the fuel injection device **10**.

The feed pump **4** is an electrically driven pump. The feed pump **4** is housed in the fuel tank **3**. The feed pump **4** is connected to the high-pressure fuel pump **5** through a fuel pipe **8***a*. The feed pump **4** applies a predetermined feed pressure to the liquid-state fuel in the fuel tank **3** to be supplied to an inside of the high-pressure fuel pump **5**. An adjusting valve is arranged in the fuel pipe **8***a* to control the fuel pressure to a predetermined value.

The high-pressure fuel pump **5** is installed to the combustion engine **2**. The high-pressure fuel pump **5** is driven by drive force generated by an output shaft of the combustion engine **2**. The high-pressure fuel pump **5** is connected to the common rail **6** through a fuel pipe **8***b*. The high-pressure fuel pump **5** applies pressure to the fuel, which is supplied by the feed pump **4**, to supply the fuel to the common rail **6**. The high-pressure fuel pump **5** has a solenoid valve that is electrically connected to the ECU **7**. The opening and closing of the solenoid valve are controlled by the ECU **7**. The ECU **7** controls the solenoid valve to adjust the pressure of the fuel, which is supplied from the high-pressure fuel pump **5** to the common rail **6**, to a predetermined value.

The common rail **6** is a pipe-shaped member made of a metal material such as chromium molybdenum steel. The common rail **6** has a plurality of branch components **6***a*. The number of the branch components **6***a* corresponds to the number of cylinders per bank of the combustion engine. Each of the branch components **6***a* is connected to the fuel injection device **10** through a fuel pipe forming a supply channel **8***c*. The fuel supply system **1** has a plurality of the fuel injection devices **10**. The fuel injection device **10** and the high-pressure fuel pump **5** are connected to each other through a fuel pipe forming a return channel **8***d*. The common rail **6** temporarily stores high-pressure fuel supplied from the high-pressure fuel pump **5** therein. The common rail **6** distributes the high-pressure fuel to the fuel injection devices **10** through the supply channels **8***c*. The common rail **6** is equipped with a common rail sensor **6***b* at the one of the two end portions of the common rail **6** in an axial direction thereof. The common rail **6** is equipped with a pressure regulator **6***c* at the other end portion of the common rail **6**. The common rail sensor **6***b* is electrically connected to the ECU **7** to detect the pressure and temperature of the high-pressure fuel and output signals to the ECU **7**. The pressure regulator **6***c* maintains the pressure of the high-pressure fuel at a constant value, and decompresses excess fuel to discharge it out of the common rail **6**. The excess fuel passing through the pressure regulator **6***c* is returned to the fuel tank **3** through a channel of a fuel pipe **8***e*, which causes the common rail **6** to communicate with the fuel tank **3**.

The fuel injection device **10** is a fuel injection valve that directly injects high-pressure fuel from injection holes **11** to the combustion chamber **2***b*. The fuel injection device **10** has a valve mechanism that controls the injection of the high-pressure fuel from the nozzle holes **11** based on control signals from the ECU **7**. The valve mechanism includes a main valve **12**, which allows or interrupts the injection of the high-pressure fuel, and a control valve **13**. For driving and controlling the valve mechanism, the fuel injection device **10** uses a portion of the high-pressure fuel supplied form the supply channel **8***c*. The fuel used for driving and controlling the valve mechanism is discharged into the return channel **8***d*, which causes the fuel injection device **10** to communicate with the high-pressure fuel pump **5**, and then it returns to the high-pressure fuel pump **5**. The fuel injection device **10** is inserted and fitted into an insertion hole arranged in the head member **2***a* of the combustion engine **2**. The fuel injection device **10** injects the high-pressure fuel with an injection pressure of a range from 160 to 220 mega Pascal (MPa).

The ECU **7** is constructed of a microcomputer or the like. The ECU **7** is electrically connected to a plurality of sensors. The sensors electrically connected to the ECU **7** can include the common rail sensor **6***b* described above, a rotational speed sensor for detecting the rotational speed of the combustion engine **2**, a throttle sensor for detecting a throttle opening, an air flow sensor for detecting the volume of intake air, a boost pressure sensor for detecting a boost pressure, a water temperature sensor for detecting a cooling water temperature, and an oil temperature sensor for detecting the oil temperature of lubricating oil. The ECU **7** outputs electric signals, for controlling the opening and closing of the solenoid valve of the high-pressure fuel pump **5** and the valve mechanism of each fuel injection device **10** based on the signals from the sensors, to the solenoid valve of the high-pressure fuel pump **5** and to each fuel injection device **10**.

FIG. **2** is a cross-sectional view of the fuel injection device **10** of the first embodiment. FIG. **3** is an enlarged view of the fuel injection device **10** of the first embodiment. In FIGS. **2** and **3**, the cross sections of different components are shown respectively for clarifying the locations of the passages. The fuel injection device **10** includes a driving part **20**, a control body **30**, a nozzle needle **90** and a floating plate **100**.

In FIG. **2**, the driving part **20** is housed in the control body **30**. The driving part **20** is a pilot-operated type solenoid valve. The driving part **20** constitutes the control valve **13**. The driving part **20** includes a solenoid **21**, a fixed member **22**, a movable member **23**, a spring **24**, a valve seat member **25**, and a terminal **26**. The terminal **26** is a current-carrying member. One end part of the terminal **26** is exposed to an outside of the control body **30**. The other end part of the terminal **26** is connected to the solenoid **21**. The solenoid **21** is supplied with a pulse current from the ECU **7** through the terminal **26**. When the solenoid **21** is supplied with the pulse current, it generates a magnetic field circling along the axial direction thereof. The fixed member **22** is a cylindrical member made of a magnetic material. The fixed member **22** is magnetized in the magnetic field generated by the solenoid **21**. The movable member **23** has cylindrical shape having two steps and is made of a magnetic material. The movable member **23** is arranged at a tip side in an axial direction of the fixed member **22**. The movable member **23** is attracted toward the fixed member **22** when the solenoid **21** is magnetized. The spring **24** is a coil spring. The spring **24** urges the movable member **23** in a direction separating from the fixed member **22**. The valve seat member **25** forms a pressure control valve **27** together with a control valve seat portion **52** of the control body **30**. The valve seat member **25** is arranged at an end portion of the movable member **23** in an axial direction thereof. The valve seat member **25** is seated on the control valve seat portion **52** to limit the flow of the fuel. When the magnetic field of the solenoid **21** is not generated, the valve seat member **25** is seated on the control valve seat portion **52** by the biasing force of the spring **24**. When the magnetic field of the solenoid **21** is generated, the valve seat member **25** is separated from the control valve seat portion **52**.

The control body **30** has a nozzle body **40**, an orifice member **50**, a holder **60**, a retaining nut **70**, and a cylinder **80**. The nozzle body **40**, the orifice member **50** and the holder **60** are arranged in this order from a tip side having the injection holes **11**. The control body **30** defines an inflow passage **31**, an outflow passage **32**, a main supply passage **33**, and a pressure chamber **34**. A bottom surface of the orifice member **50** of the control body **30** provides an abutting surface **51**, which is exposed to the pressure chamber **34**. One end of the inflow passage **31** communicates with the supply channel **8**_c_. The other end of the inflow passage **31** communicates with an inflow port **31**_a_ that is opened to the abutting surface **51**. One end of the outflow passage **32** communicates with the return channel **8**_d_ through the pressure control valve **27**. The other end of the outflow passage **32** communicates with an outflow port **32**_a_ opened to the abutting surface **51**. The pressure chamber **34** is defined by the cylinder **80**, the orifice member **50** and the nozzle needle **90**. The high-pressure fuel passing through the supply channel **8**_c_ can flow into the pressure chamber **34** from the inflow port **31**_a_. The fuel in the pressure chamber **34** can flow into the return channel **8**_d_ through the outflow port **32**_a_. Control passages are provided by the inflow passage **31** and the outflow passage **32**. The fuel flows inside the control passages for controlling the fuel pressure in the pressure chamber **34**.

The nozzle body **40** is made of a metal material such as chromium molybdenum steel and has a cylindrical shape having a bottom portion. The nozzle body **40** has a nozzle needle housing portion **41**, a valve seat portion **42**, and the nozzle holes **11**. The nozzle needle housing portion **41** is formed along an axial direction of the nozzle body **40** to be configured to a cylindrical hole shape and to hold the nozzle needle **90**. High-pressure fuel is supplied into the nozzle needle housing portion **41**. The valve seat portion **42** is arranged on a bottom wall of the nozzle needle housing portion **41**. The valve seat portion **42** is configured to contact the tip end of the nozzle needle **90**. The valve seat portion **42** is adapted as a fixed-side valve seat of the valve that allows or interrupts the flow of the high-pressure fuel. The injection holes **11** are located on a downstream side of the valve seat portion **42** in the fuel flow direction. A plurality of the nozzle holes **11** are formed to radially extend from the inside of the nozzle body **41** to the outside thereof. When the high-pressure fuel passes through the injection holes **11**, the high-pressure fuel is atomized to be diffused. Thereby the fuel may be easily mixed with air. The nozzle body **40** is also referred to as a nozzle member or a valve body. The nozzle body **40** defines a high-pressure fuel passage therein. The injection holes **11** injecting the high-pressure fuel into the combustion chamber of the engine are arranged at a tip end of the nozzle body **40**.

The cylinder **80** is formed in the shape of a circular cylinder made of a metal material. The cylinder **80** defines the pressure chamber **34** together with the orifice member **50** and the nozzle needle **90**. The cylinder **80** is arranged in the nozzle needle housing portion **41** and located coaxially with the nozzle needle housing portion **43**. An end surface of the cylinder **80** is located on a side of the orifice member **50** in the axial direction thereof. The end surface of the cylinder **80** is pressed to the abutting surface **51** of the orifice member **50**. As a result, the cylinder **80** is fixed to the orifice member **50** to be held by the orifice member **50**. The cylinder **80** can be moved relative to the orifice member **50**. However, the cylinder **80** defines the pressure chamber **34** together with the orifice member **50**, so that the cylinder **80** can be considered to belong to the orifice member **50**. On the other hand, the location of the cylinder **80** in a radial direction thereof is defined by the nozzle body **40** together with the nozzle needle **90**. Therefore, the cylinder **80** can also be considered to belong to the nozzle body **40**.

In FIG. **3**, the orifice member **50** is made of a metal material such as chromium molybdenum steel and has a cylindrical shape. The orifice member **50** is arranged to be held between the nozzle body **40** and the holder **60**. The orifice member **50** forms the abutting surface **51**, the control valve seat portion **52**, the inflow passage **31**, the outflow passage **32**, and the main supply passage **33**. The abutting surface **51** is formed in the orifice member **50** at the side of the nozzle body **40** in a central portion in the radial direction thereof. The abutting surface **51** is surrounded by the cylinder **80** to be configured in a circular shape. The control valve seat portion **52** is arranged at one of two end surfaces of the orifice member **50**, which is a side of the holder **60** in an axial direction of the orifice member **50**. The control valve seat portion **52** configures the pressure control valve **27** together with the valve seat member **25**. The inflow passage **31** is inclined with respect to the center axial direction of the orifice member **50**. The outflow passage **32** is extended toward the control valve seat portion **52** from the central portion of the abutting surface **51** in the radial direction thereof. The outflow passage **32** is inclined with respect to the center axial direction of the orifice member **50**. The main supply passage **33** causes the supply channel **8***c* to communicate with the nozzle needle housing portion **41**.

The orifice member **50** forms an inflow recess portion **53**, an outflow recess portion **54**, and the double annular abutting surface **51** on a surface that is opposed to the floating plate **100**. The inflow recess portion **53** is configured into an annular groove shape that is coaxial with a central axis AX**50** of the orifice member **50**. The inflow recess portion **53** is depressed from the axial end face of the abutting surface **51**. The inflow port **31***a* is opened at the inflow recess portion **53**. The outflow recess portion **54** is configured into an annular groove shape to be coaxial with a central axis AX**50** of the orifice member **50**. The outflow recess portion **54** is defined at the radially central portion of the orifice member **50**. The outflow recess portion **54** is depressed from the tip end face of the abutting surface **51** to be in a circular shape. The inflow recess portion **53** is defined at a radially outer side of the outflow recess portion **54**. An inner ring of the abutting surface **51** is located between the inflow recess portion **53** and the outflow recess portion **54**. The inflow recess portion **53** and the outflow recess portion **54** are separated from each other by a flat sealing surface formed by the inner ring of the abutting surface **51**. When the tip end face of the abutting surface **51** contacts the floating plate **100**, the flat sealing surface of the inner ring completely separates the inflow recess portion **53** from the outflow recess portion **54**. An outer ring of the abutting surface **51** is located at a radially outer side of the inflow recess portion **53**. The inflow recess portion **53** and the nozzle needle housing portion **41** are separated from each other by a flat sealing surface provided by the outer ring of the abutting surface **51**. When the tip end face of the abutting surface **51** contacts the floating plate **100**, the flat sealing surface of the outer ring completely separates the inflow recess portion **53** from the nozzle needle housing portion **41**.

A sealing surface **55** is arranged at an end surface of the orifice member **50** which is opposed to the nozzle body **40**. The sealing surface **55** is located at radially outer side of the main supply passage **33**. A sealing surface **43** is arranged at an end surface of the nozzle body **40** which is opposed to the orifice member **50**. The sealing surface **43** is located at radially outer side of the nozzle needle housing portion **41**. The sealing surfaces **43**, **55** provide the sealing portion to seal the high-pressure fuel in a space between the nozzle body **40** and the orifice member **50**.

The orifice member **50** is also referred to as a housing member or an orifice plate. The orifice member **50** is formed to face the end portion of the nozzle needle **90**. The orifice member **50** defines the pressure chamber **34**, which adjusts the fuel pressure applied to the nozzle needle **90** to control the movement of the nozzle needle **90**. In addition, the orifice member **50** defines the inflow passage **31**, which introduces high-pressure fuel into the pressure chamber **34**, and the outflow passage **32**, which discharges fuel out of the pressure chamber **34**.

The holder **60** is made of a metal material such as chromium molybdenum steel and has a cylindrical shape having a bottom portion. The holder **60** includes longitudinal holes **61**, **62** and a socket portion **63**. The longitudinal holes **61**, **62** are defined along the axial direction of the holder **60**. The longitudinal hole **61** is a fuel channel that causes the supply channel **8***c* to communicate with the inflow passage **31**. The driving part **20** is held at the side of the orifice member **50** in the longitudinal hole **62**. The socket portion **63** is formed at the side that is opposite from the orifice member **50** in the longitudinal hole **62** to block the opening of the longitudinal hole **62**. One end of the terminal **26** of the driving part **20** projects into an inside of the socket portion **63**. The socket portion **63** is a connector that is possible to be fitted with a plug electrically connected to the ECU **7**. When the socket portion **63** is connected to the plug, a pulse current is possible to be supplied to the driving part **20** from the ECU **7**.

The retaining nut **70** is made of a metal material and has a cylindrical shape with two steps. The retaining nut **70** holds a portion of the nozzle body **40**, the orifice member **50**, and a portion of the holder **60**. The retaining nut **70** is threaded onto the end portion of the holder **60** adjacent to the orifice member **50**. The retaining nut **70** has a stepped portion **71** on the inner peripheral wall portion thereof. The stepped portion **71** limits the movement of the nozzle body **40**. When the retaining nut **70** is fitted to the holder **60**, the nozzle body **40** and the orifice member **50** is pressed toward the side of the holder **60**. The holder **60** and the retaining nut **70** hold the nozzle body **40** and the orifice member **50** to be fixed in an axial direction thereof. The holder **60** and the retaining nut **70** are fixing members for fixing the nozzle body **40** and the orifice member **50** in the axial direction thereof.

The nozzle needle **90** is made of a metal material such as high-speed tool steel and is configured in a generally cylindrical shape. The nozzle needle **90** includes a piston portion **91**, sliding contact portions **92**, and a seat portion **93**. The piston portion **91** is a portion of the cylindrical outer surface of the nozzle needle **90** which is located inside the cylinder **80**. The piston portion **91** is arranged within the cylinder **80** to be slidably supported by an inner wall of the cylinder **80**. The sliding contact portions **92** are arranged one after another at equal intervals on an outer circular peripheral surface of the nozzle needle **90**. The sliding contact portions **92** are in contact with the inner surface of the nozzle body **40**. The sliding contact portions **92** allow the nozzle needle **90** to slide along the axial direction thereof in the nozzle body **40**. The seat portion **93** is arranged at one of two end surfaces of the nozzle needle **90** in an axial direction thereof, which is opposite from the pressure chamber **34**. The seat portion **93** can be seated on the valve seat portion **42**. The seat portion **93** and valve seat portion **42** configure the main valve **12** that allows or interrupts the flow of the high-pressure fuel to the injection holes **11** in the nozzle needle housing portion **41**. A circular collar member **96** is set to the stepped portion of the nozzle needle **90**. The nozzle needle **90** is also referred to as a valve member. The nozzle needle **90** moves in the nozzle body **40** in the axial direction thereof to allow or interrupt the flow of the high-pressure fuel to the injection holes **11**.

A return spring **97** is provided between the cylinder **80** and the nozzle needle **90** in a compressed state. The cylinder **80** is in contact with the orifice member **50** such that the return spring **97** is provided between the orifice member **50** and the nozzle needle **90**. The nozzle needle **90** is biased to a valve closing side by a return spring **97**. The return spring **97** is a coil spring. One axial direction end of the return spring **97** contacts the collar member **96**, and the other end of the return spring **97** contacts the end surface of the cylinder **80**. The nozzle needle **90** reciprocates along the axial direction of the cylinder **80** with response to the pressure difference between the fuel pressure applied to the piston portion **91** and the pressure of the high-pressure fuel flowing into the nozzle needle housing portion **41**. The nozzle needle **90** makes the seat portion **93** to be seated on and separated from the valve seat portion **42** to control the opening and closing of the main valve **12**.

The floating plate **100** is held within the cylinder **80**. The floating plate **100** is a control member to control the flow of the fuel that is introduced into and discharged from the pressure chamber **34**. The floating plate **100** forms the control valve **13** together with the driving part **20** and the pressure control valve **27**. The floating plate **100** is a cylindrical shaped member made of a metal material. The floating plate **100** is arranged to be smoothly slidable in the pressure chamber **34**. A center axis of the floating plate **100** is located along a center axis of the cylinder **80**. The floating plate **100** is arranged coaxially with the cylinder **80**. The floating plate **100** is arranged to be capable of reciprocating in the axial direction thereof. One of end surfaces of the floating plate **100**, which is opposed to the abutting surface **51**, can contact the abutting surface **51**. A sufficiently large clearance is defined between an outer circular peripheral surface of the floating plate **100** and an inner surface of the cylinder **80** to allow fuel to pass between them. A communication hole **101** is defined at a center portion of the floating plate **100** to penetrate through the floating plate **100** in the axial direction thereof. The communication hole **101** causes the pressure chamber **34** to communicate with the outflow passage **32**. The communication hole **101** is also a throttle portion. The communication hole **101** limits the amount of the fuel flowing through the communication hole **101**.

When the floating plate **100** is separated from the abutting surface **51**, the fuel flows from the inflow port **31***a* into the pressure chamber **34** through a clearance between the floating plate **100** and the cylinder **80**. When the floating plate **100** is in contact with the abutting surface **51**, the fuel flows from the pressure chamber **34** through the communication hole **101** and flows out of the outflow port **32***a*. When the floating plate **100** is in contact with the abutting surface **51**, the communication between the inflow port **31***a* and the pressure chamber **34** is interrupted. The floating plate **100** and the orifice member **50** provide a channel switching valve, which switches between the introduction of the high-pressure fuel flowing into the pressure chamber **34** and the discharge of the fuel flowing out of the pressure chamber **34**.

The floating plate **100** is a pressure-response type control member that is moved based on the amount of the pressure controlled with the pressure control valve **27**. The floating plate **100** arranged within the pressure chamber **34** contacts and separates from the orifice member **50** to allow or interrupt the communication between the inflow passage **31** and the pressure chamber **34**. In addition, a radial location of the floating plate **100** is determined with the nozzle body **40**. The orifice member **50** and the floating plate **100** form the flat sealing surface that allows or interrupts the communication between the inflow passage **31** and the pressure chamber **34**.

A plate spring **110** is a coil spring. An axial direction end of the plate spring **110** is seated on the end surface of the floating plate **100**. The other end of the plate spring **110** is seated on a pressure receiving surface **94**. The plate spring **100** is provided between the floating plate **100** and the nozzle needle **90** in a compressed state. The plate spring **110** causes the floating plate **100** to be biased to the side of the abutting surface **51**.

In FIG. **3**, an inner surface of the cylinder **80** forms an inner wall surface **81** that exposed to the pressure chamber **34** in the control body **30**. The inner wall surface **81** forms an enlarged diameter portion **82** and a reduced diameter portion **83**. The enlarged diameter portion **82** is located at the side of the orifice member **50**. The inflow port **31***a* and the outflow port **32***a* are located in an inside of the enlarged diameter portion **82**. The reduced diameter portion **83** is located at a side that is opposite from the orifice member **50** in the axial direction of the cylinder **80** with respect to the floating plate **100**. The reduced diameter portion **83** holds the end portion of the nozzle needle **90** to be slidable along an axial direction thereof. The reduced diameter portion **83** forms a cylinder side sliding surface. The reduced diameter portion **83** forms a cylinder bore. With reference to an inner diameter of the cylinder **80**, an inner diameter of the reduced diameter portion **83** is smaller than an inner diameter of the enlarged diameter portion **82**.

The cylinder **80** holds the piston portion **91** arranged at the end portion of the nozzle needle **90**. The cylinder **80** is set to be pressed toward the orifice member **50**, and thereby it defines the pressure chamber **34** together with the orifice member **50**.

The piston portion **91** is located in an inside of the reduced diameter portion **83**. The piston portion **91** is held to be slidable relative to the reduced diameter portion **83**. The piston portion **91** forms the pressure receiving surface **94** and the spring housing portion **95**. The pressure receiving surface **94** is formed of the one of two axial direction end portions of the nozzle needle **90**, which is located at the side of the pressure chamber **34** that is opposite from the seat portion **93**. The pressure receiving surface **94** defines the pressure chamber **34**. The pressure receiving surface **94** receives fuel pressure in the pressure chamber **34**. The spring housing portion **95** is a cylindrical hole formed coaxially with the nozzle needle **90** in the radial central portion of the pressure receiving surface **94**. The spring housing portion **95** holds a portion of the plate spring **110**.

The floating plate **100** is held within the enlarged diameter portion **82**. A sufficiently large clearance is defined between the outer circular peripheral surface of the floating plate **100** and an inner surface of the enlarged diameter portion **82** of the cylinder **80** to allow fuel to pass therebetween.

The fuel supply system **1** supplies the high-pressure fuel to fuel injection device **10**. The fuel injection device **10** injects fuel based on the signals from the ECU **7**.

When the ECU **7** does not output the signals, the pressure control valve **27** is blocked. The high-pressure fuel is supplied to an inside of the nozzle needle housing portion **41**. On the other hand, the high-pressure fuel supplied from the inflow port **31***a* to the inflow recess portion **53** causes the floating plate **100** to separate from the abutting surface **51**. At this time, the inside pressure of the outflow recess portion **54** becomes equal to that of the pressure chamber **34** due to the communication between the recess portion **54** and the pressure chamber **34** through the communication hole **101**. Therefore, the high-pressure fuel in the inflow recess portion **53** presses the floating plate **100** down, thereby flowing into the pressure chamber **34**. When the inside pressure of the pressure chamber **34** is raised, the floating plate **100** is seated on the abutting surface **51**. The difference between the inside pressure of the nozzle needle housing portion **41** and the inside pressure of the pressure chamber **34** is small. Therefore, the nozzle needle **90** is seated on the valve seat portion **42** to block fuel injection from the injection holes **11**.

When the magnetic field of the solenoid **21** is generated with the signals from the ECU **7**, the pressure control valve **27** is opened. When the pressure control valve **27** is opened, the inside fuel of the pressure chamber **34** is discharged through the communication hole **101**. Therefore, the inside fuel pressure of the pressure chamber **34** is reduced. At this time, inside pressure of the outflow recess portion **54** is low, so that the floating plate **100** remains to be seated on the abutting surface **51**. When the inside fuel pressure of the pressure chamber **34** becomes low, the high-pressure fuel supplied into the nozzle needle housing portion **41** urges the nozzle needle **90** toward the side of the pressure chamber **34** with high speed with resistance to the force of the return spring **97**. As a result, the nozzle needle **90** is separated from the valve seat portion **42** to start the fuel injection from the injection holes **11**.

When the magnetization of the solenoid **21** is stopped based on the signals from the ECU **7**, the pressure control valve **27** is closed. Therefore, the inside pressure of the outflow recess portion **54** becomes equal to the inside pressure of the pressure chamber **34** due to the communication between the recess portion **54** and the pressure chamber **34** caused by the communication hole **101**. As a result, the high-pressure fuel supplied into the inflow recess portion **53** from the inflow port **31***a* presses the floating plate **100** slightly down, thereby flowing into the pressure chamber **34**. When the inside pressure of the pressure chamber **34** is raised, the floating plate **100** is seated on the abutting surface **51**. When the inside pressure of the pressure chamber **34** is raised, the nozzle needle **90** is seated on the valve seat portion **42** to block the fuel injection from the injection holes **11**.

In FIG. **3**, the structure of the fuel injection device **10** for accurately setting the orifice member **50** and the floating plate **100** to proper locations will be described. The enlarged diameter portion **82** of the cylinder **80** guides the floating plate **100**. Therefore, the radial location of the floating plate **100** is set by the enlarged diameter portion **82**. The radial location of the cylinder **80** is set by the piston portion **91** of the nozzle needle **90**. Furthermore, the radial location of the nozzle needle **90** is set by the nozzle body **40**. Therefore, for accurately setting the radial location of the floating plate **100** relative to the orifice member **50**, it is necessary to accurately set the locations of the orifice member **50** and the nozzle body **40**.

The orifice member **50** includes a large circular peripheral surface **56** and a small circular peripheral surface **57**. The large circular peripheral surface **56** is located at the side of the holder **60**. The small circular peripheral surface **57** is located at the side of the nozzle body **40**. The diameter of the small circular peripheral surface **57** is smaller than that of the large circular peripheral surface **56**. A stepped portion, which has the radial direction width RW, is formed between the large circular peripheral surface **56** and the small circular peripheral surface **57**. The stepped portion includes an annular stepped surface **58**. The small circular peripheral surface **57** is an outer circular peripheral surface of a column that extends along the axial direction of the fuel injection device **10**. The small circular peripheral surface **57** is the outer circular peripheral surface of the column and formed coaxially with the orifice member **50**. The inflow recess portion **53** and the outflow recess portion **54**, which define the contact surface between the orifice member **50** and the floating plate **100**, are formed coaxially with the orifice member **50**. The small circular peripheral surface **57** is located radially outside the sealing surface **55**. The small circular peripheral surface **57** is used as a first circular peripheral surface **57**.

A circular peripheral surface **44** is arranged at the end portion of the nozzle body **40** adjacent to the orifice member **50**. The circular peripheral surface **44** is an outer peripheral surface of a column that extends along the axial direction of the fuel injection device **10**. The circular peripheral surface **44** is the outer peripheral surface of the column that is formed coaxially with the nozzle body **40**. The nozzle needle housing portion **41**, which indirectly defines the radial location of the floating plate **100**, is formed coaxially with the orifice member **50**. The circular peripheral surface **44** is used as a second circular peripheral surface **44**. The diameter of the second circular peripheral surface **44** is equal to that of the first circular peripheral surface **57**.

An annular positioning member **120** is provided at the radially outer side of the first circular peripheral surface **57** and the second circular peripheral surface **44**. The inner diameter of the positioning member **120** is slightly greater than the outer diameter of the first circular peripheral surface **57** and the outer diameter of the second circular peripheral surface **44**. The first circular peripheral surface **57** contacts almost entire inner peripheral surface of the positioning member **120**. The second circular peripheral surface **44** contacts almost entire inner peripheral surface of the positioning member **120**. The positioning member **120** is fitted to the second circular peripheral surface **44** of the nozzle body **40**, and is fitted to the first circular peripheral surface **57** of the orifice member **50**. The positioning member **120** is a positioning member that set the radial locations of the nozzle body **40** and the orifice member **50**.

The positioning member **120** is fitted to the outer circular peripheral surface **44** of the nozzle body **40**, and is fitted to the outer circular peripheral surface **57** of the orifice member **50**. The positioning member **120** is the only one positioning member for setting the radial locations of the nozzle body **40** and the orifice member **50**.

The positioning member **120** allows the rotation of the nozzle body **40** relative to the orifice member **50**. Portions defined between the nozzle body **40** and the orifice member **50**, to which fuels having different pressure are supplied respectively, are formed coaxially with the fuel injection device **10** to be separated from each other. Specifically, the passages **31**, **32**, **33** are opened at the end surface of the orifice member **50** to be separated from each other at equal intervals in a radial direction of the fuel injection device **10** from the center axis thereof. Furthermore, the inflow recess portion **53**, the outflow recess portion **54**, the pressure chamber **34** and the nozzle needle housing portion **41** are located coaxially with the fuel injection device **10**. Therefore, if the nozzle body **40** is rotated relative to the orifice member **50**, the function of the fuel injection device **10** can be maintained.

Moreover, the retaining nut **70** used as a fixing member is located to cover both the nozzle body **40** and the orifice member **50**, and located in the radially outside of the positioning member **120**. The positioning member **120** is held by the retaining nut **70** in an axial direction thereof.

FIG. **4** is an enlarged cross-sectional view of the fuel injection device showing the positioning member **120**. The positioning member **120** is made of a metal material and has a cylindrical shape. The positioning member **120** has two enlarged inner diameter portions at both ends. The diameters of the enlarged inner diameter portions become larger toward the ends of the positioning member **120**. The positioning member **120** has an inner circular peripheral surface **121** and slope **122**, **123**. The inner circular peripheral surface **121** is an inner surface of a cylinder hollow that contacts the first circular peripheral surface **57** and the second peripheral surface **44** to set the locations of the nozzle body **40** and the orifice member **50**. The length GH of the inner circular peripheral surface **121** is an effective length of the positioning member **120**. When the positioning member **120** is held in the retaining nut **70** and the retaining nut **70** is screwed with a proper location, the first peripheral surface **57** and the second peripheral surface **44** are located within the range of the length GH in the axial direction. The radial width GW of the positioning member **120** and the width RW of the stepped surface **58** of the orifice member **50** satisfy the following equation $GW<RW$. The radial width GW and the width RW can be set to satisfy the following equation $GW \leq RW$.

The slope **122** is inclined with respect to the inner circular peripheral surface **121** to make the width of the positioning member **120** become smaller toward the axial end thereof. The slope **122** provides an enlarged inner diameter portion, in which the diameter becomes larger from the side of the inner circular peripheral surface **121** to the end of the positioning member **120**. When the slope **122** and the orifice member **50** are connected to each other, the slope **122** guides the first peripheral surface **57** toward the inner circular peripheral surface **121**. Therefore, the slope **122** guides the orifice member **50** to the fitting location of the orifice member **50** and the positioning member **120**.

The slope **123** is inclined with respect to the inner circular peripheral surface **121** to make the width of the positioning member **120** become smaller toward the axial end thereof. The slope **123** provides an enlarged inner diameter portion, in which the diameter becomes larger from the side of the inner circular peripheral surface **121** to the end of the positioning member **120**. When the positioning member **120** and the nozzle body **40** are connected to each other, the slope **122** guides the second peripheral surface **57** toward the inner circular peripheral surface **121**. Therefore, the slope **123** guides the nozzle body **40** to the fitting location of the nozzle body **40** and the positioning member **120**.

The manufacturing method and processes of the fuel injection device **10** will be described below. In a preparation process, the components such as the nozzle body **40**, the orifice member **50** and the positioning member **120** are formed as shown in the drawings. Then, the orifice member **50** is fitted to the positioning member **120**. At this time, the slope **122** guides the first peripheral surface **57** toward the inner circular peripheral surface **121**. The positioning member **120** is disposed to contact the stepped surface **58**. The stepped surface **58** is used as a stopper for limiting the movement of the positioning member **120**. The stepped surface **58** sets the axial position of the positioning member **120**. The axial length GC of the positioning member **120** and the axial length RL of the first peripheral surface **57** adjacent to the stepped surface **58** satisfy the following equation GC>RL. Therefore, when the positioning member **120** is fitted to the orifice member **50**, the inner circular peripheral surface **121** of the positioning member **120** projects from the orifice member **50**. The projecting length GP of the positioning member **120** includes the axial length of the inner circular peripheral surface **121** and the slope **123**. The nozzle body **40** is set at the proper location by the positioning member **120** with a portion having the effective length GE of the inner circular peripheral surface **121**.

The nozzle needle **90**, the collar member **96**, the return spring **97**, the cylinder **80**, the plate spring **110**, and the floating plate **100** are fitted in the nozzle body **40**. At this time, the return spring **97** and the plate spring **110** have free length, respectively. Therefore, the cylinder **80** and the floating plate **100** project from the end surface of the nozzle body **40**.

Then, the nozzle body **40** installed with the components, such as the return spring **97**, is temporarily fitted to the orifice member **50**. In the temporary assembling process, the second peripheral surface **44** is inserted into the positioning member **120** through the side of the slope **123**. At this time, the second peripheral surface **44** is in contact with the orifice member **50** and gradually compresses the plate spring **110** to be inserted into the positioning member **120**. The second peripheral surface **44** is inserted into the positioning member **120** until the cylinder **80** contacts the orifice member **50**.

The plate spring **110** is more compressible than the return spring **97**. Therefore, at the time of temporarily assembling the nozzle body **40** in the positioning member **120**, the plate spring **110** is easy to be compressed, however, the return spring **97** is hardly compressed. The plate spring **110** is possible to be compressed by the weight of the nozzle body **40** and the nozzle needle **90**. When no weight is applied to the return spring **97**, the return spring **97** has a free length SF. In the assembled state of the return spring **97** as shown in HG. **3**, the return spring **97** has a compressed length SC. The difference between the free length SF and the compressed length SC is a compression amount SP of the return spring **97**. When the nozzle body **40** is temporarily assembled to the orifice member **50**, the cylinder **80** projects from the end surface of the nozzle body **40** by the compression amount SP. Therefore, in the temporarily assembled state, the first peripheral surface **57** and the second peripheral surface **44** are separated from each other in the axial direction thereof by the compression amount SP.

The projecting length GP of the positioning member **120** is set such that the nozzle body **40** and the orifice member **50** are located within the inner circular peripheral surface **121** to set its radial position even in the temporarily assembled state. The projecting length GP is set such that when only the cylinder **80** contacts the cylinder member **50**, the second peripheral surface **44** reaches the inner circular peripheral surface **121**. Specifically, the axial length RL of the first peripheral surface **57** and the axial length GC of the positioning member **120** are set such that the length GP of the projection of the positioning member **120** projecting in the axial direction thereof from the first peripheral surface **57** is greater than the compression amount SP of the return spring **97** such that GP>SP. More specifically, the effective length GE and the compression amount SP of the return spring **97** are set such that GE>SP. Therefore, in the temporarily assembled state, i.e., before the return spring **97** is compressed, the orifice member **50** and the nozzle body **40** can be set to the proper locations, respectively.

Next, the retaining nut **70** is screwed to the orifice member **50** and the nozzle body **40**. In the process of screwing the retaining nut **70**, the return spring **97** is gradually compressed. When the nozzle body **40** directly contacts the orifice member **50**, the process of screwing the retaining nut **70** is finished. The positioning member **120** is provided between the orifice member **50** and the retaining nut **70** in the axial direction thereof to be held therebetween. More specifically, the positioning member **120** is held on a gap between the stepped surface **58** and the retaining nut **70** in the axial direction thereof.

In the present embodiment, the manufacturing method of the fuel injection device **10** includes the above described manufacturing processes. Therefore, the nozzle body **40** and the orifice member **50** are accurately set at the proper locations in the radial direction thereof, while the nozzle body **40** and the orifice member **50** are assembled.

FIG. **5** is an enlarged cross-sectional view of a proper alignment of the fuel injection device **10** of the first embodiment. FIG. **6** is a plane view of the proper alignment of the fuel injection device **10** of the first embodiment. In the present embodiment, the nozzle body **40** and the orifice member **50** are lined by the positioning member **120** with reference surfaces, i.e., the circular peripheral surface **44** of the nozzle body **40** and the circular peripheral surface **57** of the orifice member **50**. The peripheral surfaces are formed with high accuracy relative to the center axis of the components. The positioning member **120** makes the center of the nozzle body **40** to be accurately coaxial to the center axis of the orifice member **50**. Therefore, the nozzle body **40** and the orifice member **50** are set at the proper locations respectively with high accuracy.

When the nozzle body **40** and the orifice member **50** are set at the proper locations, the center axis AX**50** of the orifice member **50** is coaxial with a center axis AX**80** of the cylinder **80**. Therefore, the floating plate **100** is set at the proper location relative to the orifice member **50** with high accuracy.

Specifically, the location of the floating plate **100** on the abutting surface **51** is the proper location of the floating plate **100**. As shown in FIG. **6**, the orifice member **50** is coaxial with a contact surface CS of the floating plate **100**. The contact surface CS is the flat sealing surface arranged between the orifice member **50** and the floating plate **100**. Therefore, fuel flows along the circumferential direction in the floating plate **100**, and fuel pressure is applied to the floating plate **100**. As a result, the motion of the floating plate **100** is stabilized. In addition, the fuel injection characteristic is stabilized. Furthermore, high accuracy can be achieved with high productivity structure in the fuel injection device **10**.

Second Embodiment

FIG. **10** is an enlarged cross-sectional view of a fuel injection device **210** of a second embodiment according to the present invention. In the following embodiments, similar components will be indicated by the same reference numerals and will not be described redundantly for the sake of simplicity. The details of the similar components are referred in the above described embodiment. The fuel injection device **210** can be applied to the fuel supply system **1** instead of the fuel injection device **10**.

The fuel injection device **210** includes orifice members **250***a*, **250***b*, instead of the orifice member **50** of the first embodiment. The orifice members **250***a*, **250***b* are formed in a column shape or a circular disk shape to be stacked with each other in an axial direction. The orifice members **250***a*, **250***b* define a plurality of fuel passages. In the orifice members **250***a*, **250***b*, main supply passages **33***a*, **33***b* are defined to cause the longitudinal hole **61** to communicate with the nozzle needle housing portion **41**.

The fuel injection device **210** does not include the floating plate **100** described in the above first embodiment. The fuel injection device **210** is equipped with a control valve **213**. The control valve **213** includes a pressure control valve **227** instead of the floating plate **100**. The control valve **227** is controlled directly by a driving portion **220**. The driving portion **220** uses a piezo-electric element as an actuator. The driving portion **220** moves a rod **223***a* with a piston **223** in the up and down direction in FIG. **10**. The pressure control valve **227** switches a high-pressure state and a low-pressure state in the pressure chamber **34** to drive the nozzle needle **90**. The pressure control valve **227** is held between the orifice members **250***a*, **250***b*. The orifice member **250***a* includes a recess portion **238** that holds the pressure control valve **227**. The recess portion **238** includes a valve body **228** and a spring **229**. The valve body **228** is possible to move in the axial direction of the fuel injection device **210** within the recess portion **238**. The spring **229** presses the valve body **228** in the axial direction thereof. The valve body **228** can move between a first position for setting the inside of the pressure chamber **34** at a high-pressure state and a second position for setting the inside of the pressure chamber **34** at a low-pressure state.

The orifice member **250***b* includes a common supply passage **235** to cause the pressure control valve **227** to communicate with the pressure chamber **34**. The common supply passage **235** causes the recess portion **238** to communicate with the pressure chamber **34** at any time. The common supply passage **235** is a commonly used passage for controlling the flow of the fuel that flows into and flows out of the pressure chamber **34**. The common supply passage **235** includes a throttle **235***a* that limits the amount of the fuel flow.

A low-pressure passage **236** is defined in the orifice member **250***a*. The low-pressure passage **236** causes the pressure control valve **227** to communicate with the return channel **8***d*. The low-pressure passage **236** is opened on the recess portion **238**. The low-pressure passage **236** can be used as an outflow passage. A valve seat **250***c* is provided around the opening of the low-pressure passage **236** in the recess portion **238**. The valve body **228** can be seated on the valve seat **250***c*. The valve body **228** and the valve seat **250***c* form a valve member that allows or interrupts the communication between the recess portion **238** and the low-pressure passage **236**. When the valve body **228** is located at the first position, the valve body **228** is seated on the valve seat **250***c* to interrupt the communication between the recess portion **238** and the low-pressure passage **236**. When the valve body **228** is located at the second position, the valve body **228** is separated from the valve seat **250***c* to allow the communication between the recess portion **238** and the low-pressure passage **236**.

An inflow passage **237** is defined in the orifice member **250***b*. The inflow passage **237** causes the nozzle needle housing portion **41** to communicate with the pressure control valve **227**. The inflow passage **237** is opened on the recess portion **238**. A valve seat **250***d* is provided around the opening of the inflow passage **237** in the recess portion **238**. The valve body **228** can be seated on the valve seat **250***d*. The valve body **228** and the valve seat **250***d* form a valve member that allows or interrupts the communication between the recess portion **238** and the inflow passage **237**. When the valve body **228** is located at the first position, the valve body **228** is separated from the valve seat **250***d* to allow the communication between the recess portion **238** and the inflow passage **237**. When the valve body **228** is located at the second position, the valve body **228** is seated on the valve seat **250***d* to interrupt the communication between the recess portion **238** and the inflow passage **237**.

The valve body **228** is directly controlled by the driving portion **220**. The rod **223***a* is provided between the piston **223** and the valve body **228**. The piston **223** is pressed toward the down direction in FIG. **10**, i.e., the direction to press the valve body **228** toward the second position, by the spring **224**. On the other hand, the valve body **228** is pressed toward the upper direction in FIG. **10**, i.e., the direction to press the valve body **228** toward the first position, by the spring **229**. The springs **224**, **229** are set to make the valve body **228** located in the first position when the high-pressure fuel is supplied in the fuel injection device **210**.

In the present embodiment, the positioning member **120** is also used in the fuel injection device **210**. The positioning member **120** is fitted to the outer circular peripheral surface **57** of the orifice member **250***b*. Furthermore, the positioning member **120** is fitted to the outer circular peripheral surface **44** of the nozzle body **40**.

The positioning member **120** is only one positioning member that sets the radial locations of the nozzle body **40** and the orifice member **250***b*. The positioning member **120** allows the rotation of the nozzle body **40** relative to the orifice member **250***b*. Portions defined between the nozzle body **40** and the orifice member **250***b*, to which the fuel having different pressure are supplied respectively, are formed coaxially with the fuel injection device **210** to be separated from each other. Specifically, the passages **33***b*, **235** are opened at the end surface of the orifice member **250***b* to be separated from each other at equal intervals in a radial direction of the fuel injection device **210** from the center axis thereof. Furthermore, the pressure chamber **34** and the nozzle needle housing portion **41** are located coaxially with the fuel injection device **210**. Therefore, if the nozzle body **40** is rotated relative to the orifice member **250***b*, the function of the fuel injection device **210** can be maintained.

Positioning members (not shown), such as pins, are provided between the orifice member **250***a* and the orifice member **250***b* and between the orifice member **250***a* and the holder **60** to position the orifice members **250***a* and the holder **60** in the radial direction and the rotational direction thereof.

The piston portion **91** provided at the end of the nozzle needle **90** is held in the cylinder **80**. The cylinder **80** is set to be pressed toward the orifice member **250***b*, and thereby the cylinder **80** defines the pressure chamber **34** together with the orifice member **250***b*. The radial location of the cylinder **80** is defined by the nozzle needle **90**. Furthermore, the radial location of the nozzle needle **90** is defined by the nozzle body **40**. The radial location of the cylinder **80** is defined by the nozzle body **40** with the nozzle needle **90**. The nozzle body **40** and the orifice member **250***b* are positioned accurately to the proper locations with the positioning member **120**, and thereby the cylinder **80** is also positioned accurately relative to the orifice member **250***b*.

In the present embodiment, when the driving portion **220** is activated, the piston **223** moves to a downside direction in FIG. **10**. Therefore, the valve body **228** moves from the first position to the second position. As a result, the fuel flows from the pressure chamber **34** to the low-pressure passage **236**, and thereby the nozzle needle **90** moves to the upper direction in FIG. **10** to inject the fuel. When the driving portion **220** is not activated, the piston **223** moves to an upper direction in FIG. **10**. Therefore, the valve body **228** moves from the second position to the first position. As a result, the fuel flows from the inflow passage **237** to the pressure chamber **34**, and thereby the nozzle needle **90** moves to the downside direction in FIG. **10** to interrupt the fuel injection.

In the present embodiment, the nozzle body **40** and the orifice member **250***b* are set at the proper locations respectively with high accuracy by the positioning member **120**. Therefore, the components are accurately set at the proper locations in the radial direction thereof relative to each other. Furthermore, the one positioning member **120** is used in the present embodiment, so that the high productivity can be achieved. Moreover, instability of the fuel injection characteristic, which is caused by the dislocation of the nozzle body **40** and the orifice member **250***b*, can be limited in the present embodiment. Moreover, the cylinder **80** is set accurately relative to the orifice member **250***b*, so that the instability of the fuel injection characteristic that is caused by the dislocation of the nozzle body **40** and the orifice member **250***b* can be limited.

Other Embodiments

The preferred embodiments of the present invention have been described. However, the present invention is not limited to the above embodiments, and the above embodiments may be modified in various ways without departing from the spirit and scope of the invention. The configurations of the above-described components are examples and not limited to the configuration of the first embodiment. Furthermore, the components of the above embodiment and the modifications thereof may be combined in any appropriate manner within the spirit and scope of the present invention.

For example, the inner diameter of the positioning member **120** can be set to become smaller than outer diameter of the first peripheral surface **57**. In this case, the first peripheral surface **57** is fixed to the positioning member **120** by press fitting. Furthermore, the inner diameter of the positioning member **120** can be set to become smaller than outer diameter of the second peripheral surface **44**. In this case, the second peripheral surface **44** is fixed to the positioning member **120** by press fitting.

A stepped portion can be formed in the nozzle body **40** similar to the case of the orifice member **50**, and the circular peripheral surface **44** can be formed by the small diameter portion of the nozzle body **40**. Furthermore, the stepped portion can be arranged on only the nozzle body **40** instead of the orifice member **50** to provide the circular peripheral surface **44**. In this case, the axial location of the positioning member **120** is set by the nozzle body **40**.

The outer diameter of the first peripheral surface **57** and the outer diameter of the second peripheral surface **44** can be formed in different sizes, and it is possible to make the inner surface of the positioning member **120** with a stepped surface that is formed by the enlarged diameter portion and the small diameter portion, which correspond to the circular peripheral surfaces **57**, **44** respectively. Furthermore, the first peripheral surface **57** and the second peripheral surface **44** can include a key groove to define the location in the rotation direction thereof.

The first peripheral surface **57** and the second peripheral surface **44** can be partially conical surfaces that have slightly inclined slopes relative to the axial direction thereof. For example, the circular peripheral surface **57** arranged on the orifice member **50** can be the partially conical surface in which its outer diameter gradually becomes smaller toward the end portion thereof. The concept of the above described peripheral surfaces includes partially conical surfaces.

In the above described embodiment, the slopes **122**, **123** are arranged on the both ends of the positioning member **120**, respectively. Instead of the above described configuration, the positioning member **120** can include the only one slope, i.e., the slope **122** or the slope **123**, at one side of the end portions.

In the above described embodiment, the circular peripheral surface **44** arranged on the nozzle body **40** is an outer peripheral surface. Instead of the above described configuration, a cylindrical portion can be formed at the end portion of the nozzle body **40**, and then an inner circular peripheral surface is arranged at an inside of the cylindrical portion. In the above described modification example, the positioning member is provided in an inside of the inner circular peripheral surface to be fixed to the inner circular peripheral surface. In addition, in the above described embodiment, the circular peripheral surface **57** arranged on the orifice member **50** is the outer circular peripheral surface. Instead of the above described configuration, a cylindrical portion can be formed at the end portion of the orifice member **50**, and then an inner circular peripheral surface is arranged at an inside of the cylindrical portion. In the above described modification example, the positioning member is provided in an inside of the inner circular peripheral surface to be fixed to the inner circular peripheral surface.

Additional advantages and modifications will readily occur to those skilled in the art. The invention in its broader terms is therefore not limited to the specific details, representative apparatus, and illustrative examples shown and described.

What is claimed is:

1. A fuel injection device comprising:

a valve body having therein a passage for a high-pressure fuel, the valve body being provided with injection holes that are arranged at a tip end of the valve body to inject the high-pressure fuel to an inside of a combustion chamber of an internal combustion engine;

a valve member that moves in an axial direction of the valve body therein to allow or interrupt a supply of the high-pressure fuel to the injection holes;

a housing member that is structured to face an end of the valve body and to define a pressure chamber, which controls movement of the valve body by adjusting fuel pressure applied to the valve body, and forms control passages through which fuel flows for controlling the fuel pressure in the pressure chamber; and

a positioning member that is annular-shaped and is fixed to an outer circular peripheral surface of the valve body and fixed to an outer circular peripheral surface of the housing member, to set locations of the valve body and the housing member in a radial direction and to cover the valve body and the housing member;

a fixing member provided radially outside of the positioning member to fix the valve body and the housing member in the axial direction;

a holder threaded with the fixing member,

a cylinder holding a piston portion arranged at an end portion of the valve member, the cylinder being located to be urged toward the housing member, and the cylinder defining the pressure chamber together with the housing member, and

a control member that is provided in an inside of the pressure chamber and contacts and detaches from the housing member to at least allow or interrupt a communication between an inflow passage and an outflow passage, wherein

the valve body and the housing member are pressed toward the holder when the fixing member is fitted to the holder,

the positioning member is not in contact with the fixing member;

a radial location of the cylinder is set by the valve member,

a radial location of the valve member is set by the valve body,

the control passages include the inflow passage, which introduces fuel to the pressure chamber, and the outflow passage, which discharges the fuel out of the pressure chamber,

a radial location of the control member is defined by the valve body and the cylinder,

the housing member and the control member contact at a flat sealing surface that allows or interrupts a communication between the inflow passage and the pressure chamber,

the positioning member extends in the axial direction of the fixing member across both a sealing surface of the housing member and a sealing surface of the valve body, wherein the sealing surface of the housing member faces the sealing surface of the valve body in the axial direction, and

the sealing surface of the housing member and the sealing surface of the valve body are partially in contact with each other in the axial direction;

wherein the positioning member allows rotation of the valve body relative to the housing member.

2. The fuel injection device according to claim **1**, wherein at least one of the valve body and the housing member has a stepped surface that sets a location of the positioning member in the axial direction.

3. The fuel injection device according to claim **2**, wherein an axial length of the positioning member is larger than an axial length of the circular peripheral surface of the housing member that is adjacent to the stepped surface.

4. The fuel injection device according to claim **3**, further comprising:

a return spring provided between the housing member and the valve member to urge the valve member to a valve-close direction, wherein an axial length of the circular peripheral surface of the housing member and an axial length of the positioning member are set such that a length (GP) of a projection of the positioning member projecting in the axial direction from the circular peripheral surface of the housing member is larger than a compression amount (SP) of the return spring, such that GP>SP.

5. The fuel injection device according to claim **2**, wherein a thickness (GW) of the positioning member is less than a width (RW) of a stepped portion, such that GW<RW.

6. The fuel injection device according to claim **1**, wherein the positioning member has a slope that guides at least one of the valve body and the housing member to a fixing location.

7. The fuel injection device according to claim **1**, wherein the control passage includes a common supply passage that is commonly used for introducing the fuel into the pressure chamber and discharging the fuel out of the pressure chamber.

8. The fuel injection device according to claim **1**, wherein the fixing member is provided radially outside of the valve body and the housing member to cover at least a portion of both the valve body and the housing member.

9. The fuel injection device according to claim **1**, wherein a width of the positioning member becomes smaller toward at least one axial end thereof.

10. The fuel injection device according to claim **1**, wherein the positioning member has two enlarged inner portions at both ends thereof.

11. The fuel injection device according to claim **1**, wherein the positioning member is disposed to contact a stepped surface of the housing member so that the stepped surface limits movement of the positioning member and sets an axial position of the positioning member.

12. The fuel injection device according to claim **1**, wherein the piston portion is arranged within the cylinder to be slidably supported by an inner wall of the cylinder.

13. The fuel injection device according to claim **1**, wherein

the inflow passage communicates with an inflow port that is opened to an abutting surface of the housing member,

the outflow passage communicates with an outflow port opened to the abutting surface of the housing member,

the abutting surface of the housing member and the sealing surface of the housing member are on the same surface, and

the abutting surface of the housing member is located at a radially inner side of the sealing surface of the housing member.

14. The fuel injection device according to claim **1**, wherein the pressure chamber is defined by the cylinder, the housing member and the valve member.

15. The fuel injection device according to claim **1**, wherein the control member is configured to simultaneously seal the inflow passage and provide a throttle portion in fluid communication with the outflow passage.

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